(126×420) about 53,000 times that of a candle-flame. This is more than three times the value found by Arago for the intensity of the light from the sun's disc as compared with that from a candle-flame; so much for a Glasgow December sun!

The ·09 cm. diameter of the pin-hole, of the Glasgow observation, subtends, at 230 centimetres distance, an angle of 1/2556 of a radian; which is 23·7 times the sun's diameter (1/108 of a radian). But at 230 cm. distance the sunlight through the pin-hole amounted to 126 times the York moonlight (which was 1 candle at 230 cm. distance). Hence the Glasgow sunlight was $[(23\cdot7)^2 \times 126$ times or$]$ 71,000 times the York moonlight. We cannot therefore be *very far* wrong in estimating the light of full moon as about one-seventy-thousandth of the sunlight, anywhere on the earth. This, however, is a comparison which, because of the probably close agreement of the tints of the two lights, can probably be made with minute accuracy: and we must therefore not be satisfied with so very rough an approximation to the ratio as this 70,000. A lime light, or magnesium light, or electric arc-light, carefully made and remade with very exactly equal brilliance, for each separate observation of sunlight and moonlight, might be used for intermediary.

THE HYPOTHESIS OF ACCELERATED DEVELOPMENT BY PRIMOGENITURE, AND ITS PLACE IN THE THEORY OF EVOLUTION[1]

IN our days the student of the biological sciences may look forward towards his life-task with sincere gratitude. Gratitude not only for what has already been achieved, and for the ends that have been attained in this domain, but more especially for all that which the future promises, since the sage whose mortal remains were lately deposited in Westminster Abbey has thrown the light of his genius over regions which hitherto were shrouded in deepest obscurity and has opened new vistas on old problems, of which man has been seeking the solution for many thousands of years.

It is to him we have to give thanks that the dawn of a new life has commenced for those sciences; to him, moreover, we owe it that the twilight has only lasted a short time, and that the full light of day has shone so soon upon an extensive field. And if by this light we perceive numerous new problems, the existence of which was not even dreamt of before, and which cover the field of our work as far as the horizon reaches, still we notice that their shapes have obtained definite outlines. In future they may serve as milestones on our way onwards, before, when we were still groping in the dark, they were as many stumbling-blocks which prevented us from advancing.

If to-day I call before your mind the image of this great reformer, it is not to give you an eulogy of Darwin, whose sudden death some months ago has filled with grief the whole civilised world. He is before my mind, because I belong to the generation whose youth coincides with that of the "Origin of Species;" a generation deeply filled with gratitude towards this great master. A gratitude bursting forth with doubled intensity in him who enters upon a career in which he will have ample opportunity to continue work in that field of science to which he has become more and more attached through the inspiring influence of Darwin.

It is not only by the contents of his work that Darwin takes hold of us, it is also his personal character which leaves such a forcible impression. The history of his life, his method of work, his amiable individuality, have excited our enthusiasm over and again, and always in an increasing measure. Similar to other grand figures in the history of the world, who by their life and their example have perhaps wrought more than by their teaching—which at the hands of less eminent adepts soon took a dogmatic, *i.e.* a degenerate shape—this reformer of biological science has left behind him a remembrance which will be kept and transmitted by his followers with quite as much care and piety as the writings he has left.

What strikes us most and all at first in everything emanating from him is his passionate honesty,[2] which has already become proverbial. Never did he pass over in silence, in the interest of his argument, a point which might eventually appear to be in favour of the opposite plea. In the enumeration and refutation of such points he was always quite as careful as in the collection of positive proofs. He was never biassed, unless biassed in the good sense of the term, *i.e.* enabled, when once he was of opinion that it was necessary to choose a decided side with respect to any dubious point, to devote to the careful consideration of this point not only hours, but if necessary months and years of his life,—months and years of daily returning observations concerning what appeared to be unimportant facts, which, however, when they were afterwards brought together, permitted him to draw highly important conclusions.

Unlimited veracity and undaunted patience, two principal requirements of the true naturalist, thus found their most perfect incarnation in Darwin, and with these two for his guides, he brought together, from far and near, building stones for the completion of the grand structure which his mind had conceived. The quarries from whence he excavated those building stones were very different from those to which the scribes in biological science habitually resorted. It must be understood that since the appearance of Cuvier's "Le Règne Animal distribué d'après son Organisation," a reaction had sprung up against descriptive zoology which in many cases went further than Cuvier himself would ever have acknowledged. The numerous volumes of his excellent "Histoire naturelle des Poissons" furnish ample proof that Cuvier had always endeavoured to combine careful description of the species and conscientious sifting of all the material concerning its life history, its geographical distribution, and its synonymy with the study of the comparative anatomy of the group to which it belonged. Several of his followers have, however, concluded that since researches upon the internal organisation of so many classes of animals allowed him to make most important deductions, it was from similar researches only that anything could be expected for the future. Their ambitious aspirations could not manage to forget that a combined investigation by Cuvier and Geoffroy St. Hilaire was once described by one of the two in the following words:—"Nous ne déjeunions jamais sans avoir fait une découverte."

And so a period was opened up in which our knowledge of the internal organisation of animals was not only increased on all sides and firmly based upon facts by zealous workers, but in which this knowledge was gradually pushed into the foreground as the pre-eminent, as the only true zoology. The careful study of the species and its life history was left with a smile and a shrug of the shoulders to dilettanti and museum zoologists. In order further, to indicate how the results of researches of these men were looked upon as popular and unimportant, this new school invented the well-sounding name of "scientific zoology."

The eminent researches of von Siebold on parthenogenesis and on the freshwater fishes of Germany; Kölliker's important monograph of the Pennatulids, &c., show that even its founders were subject to impulses which drove them back into this very field, or rather that it was not they, but their less gifted followers from whom the contemptuous meaning which that combination of words gradually attained has emanated.

Thus for a certain lapse of time the wind blew from a different quarter, and attempts have repeatedly been made to call into life classifications which were based upon certain points in the internal organisation, points which were considered to be of the more importance the less they were visible. Fortunately the great masters to whom we owe comparative anatomy, and who have made it such as we know it in the present day, have not joined in this movement. Johannes Müller's "System der Plagiostomen" stands side by side with his "Comparative Anatomy of the Myxinoids," showing that this one-sided exaggeration would never have been encouraged by himself. Gegenbaur, Huxley, &c., have similarly kept aloof from the "scientific zoologists" in the stricter sense, whose narrow-minded doctrines are still pullulating, be it in a somewhat modified form. At the present day it is not so much the internal organisation which forms the shibboleth by which entrance is obtained to the holy circle of self-styled orthodox zoologists, but now it is the history of development, embryology, that gives the pass-word. This important branch of biological science has made gigantic strides of late; it counted in its foremost ranks, among the most promising and large-minded, the man whom a cruel fate had doomed to find his death in the Alps of Switzerland, the talented Balfour. He never overvalued in a petty way the labours of the select batallion of which he was one of the leaders. In the rear of this army, however, voices are heard claiming infallibility for embryology, and the splendid generalisation: "the development of the individual is a repetition on a reduced scale of the development of the race," must often serve to hide unripe attempts at classifications deduced from the developmental stages of eggs and larvæ of questionable origin, and applied to groups of animals of which the adventurous embryologist would certainly not be able to distinguish the different members specifically.

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[1] By Prof. A. A. W. Hubrecht. Inaugural Address delivered in the University of Utrecht. September, 1882.

[2] Cf. Huxley, NATURE, May, 1882.

But enough of this distressing partiality, knowing that we find a complete reaction against it, in Darwin's word and example, which will be our strongest antidote against similar influences. We are thus carried back to our starting-point, where it was observed that the value of the sources from whence Darwin has drawn so much valuable information, was scarcely recognised up to his time. He entered into connection with cattle-rearers and bird-fanciers, and gladly availed himself of the remarks of trustworthy observers who were acquainted with animals and plants in their daily life, even if they had always remained outside the pale of science.

And what far-reaching results may be obtained by careful study of the habits and life-history of animals is shown by the last volume which we owe to Darwin's hand. Here it is apparent, upon almost every page, that from conscientious observations on the habits of an animal so common as the earthworm, conclusions follow which furnish us with new and quite unexpected views about the formation and the changes of a large area of the earth's surface.

The most striking example of Darwin's all-embracing genius is obtained when his Monograph of the Cirripedia is compared with the chapters in which he enunciates and discusses his hypothesis of pangenesis. The one, the most scrupulous study of details, the comparison of slight differences both between individuals of the same species and between specifically distinct specimens; the evaluation of these distinctive characters one against the other; in one word, pure systematic zoology with all its appurtenance of patience, scrupulousness, and nearly painful conscientiousness. The other—one of the most daring hypotheses which the human understanding has ever wrought, upon which only a very limited number of observed facts can be brought to bear. A hypothesis which boldly penetrates into the most hidden secrets of organic nature; which brings the marvellous effects of heredity on a level with the reproduction of lost parts, yea even with the healing of wounds. A hypothesis which no longer looks upon the cells as the morphological units of the living organism, but which postulates the existence of a continual flow of separate minute gemmulæ, feeding and reproducing themselves, and being derived from all the cells and all the tissues in all the consecutive periods of their existence. These gemmulæ, in the individual being we have before us, circulate along paths which remain wholly unknown to us, and finally reunite in millions in every ovum, in every spermatozoon, in every bud, and in every pollen-grain.

The laws by which these inscrutable processes are governed, do not lose anything of their mysteriousness when we glance at the disparate and incomprehensible phenomena which they have to explain: atavism, in which heredity takes a sudden leap backwards into the grey mists of the past; the transmission to the child of the effects of an increased or decreased use of a limb by the parents: the reproduction of a lost limb or tail; the growth of an entire plant out of a severed portion of a leaf; the change which pollen and sperma may occasionally call forth not only in the ovules but also in the tissues of the mother-form; the hybridisation in the vegetable kingdom by the union of the cellular tissue of two plants independently of the organs of generation; the appearance of a complex metamorphosis in the course of the development of certain animal forms, the nearest allies of which are entirely devoid of anything like it; &c.

Nevertheless this hypothesis was put forward by the very same Darwin whom we have to thank for the monograph of the Cirripedia. It is clear that the frame of mind required for completing the one is widely different from that in which he enunciated the other. There is, however, a common link uniting the two. In the specific description of the Cirripeds we find him ever and again in collision with the opinion then generally accepted of the definite boundaries limiting the species, and thus this work cannot have remained without influence on the later development of his ideas. On the other hand, he looked upon the hypothesis of pangenesis as a necessary sequel, to a certain extent as "le couronnement de l'édifice" of his theory of evolution by means of natural selection.

We have not here to enter into a discussion concerning the hypothesis of pangenesis, nor to inquire into the different attacks to which it has already been exposed. I must, however, observe that with it Darwin has entered the domain of physiology, a field upon which all the questions into which the great problem of evolution may be subdivided, as heredity, influence of use and disuse of organs, adaptation to modified circumstances, must find their solution.

Whereas the physiology of man and the higher animals is developing and growing with rapidity, and what has been thought and wrought in Utrecht has largely influenced this development, Comparative Physiology, which has to track all the different problems just mentioned all through the animal kingdom down to their simplest form in the lowest organised beings, is only in its infancy. And yet this branch of science will shortly come abreast of morphology further to secure the basis of the theory of evolution and to contribute to its harmonious development. It was not by mere chance that the legislature specially mentions Comparative Physiology as a branch of science which will have to be cultivated and taught by him who is called to the chair I am about to occupy.

Although the greater part of this territory is still wrapt in obscurity, still it is at the University of Utrecht that the prospects for Comparative Physiology are promising in the highest degree, be it by the efforts of others than the legislature had in view. It must for certain be acknowledged that researches concerning the phenomena of life in the very smallest organisms, investigating their reaction towards light and oxygen, and even penetrating into the effects of hunger and thirst as manifested by these lowly-organised beings, eminently belong to the domain of Comparative Physiology. The vicinity of a laboratory in which such excellent results have already been obtained is a strong stimulus for us all towards further labour in this field.

Venturing to-day along that road, I may hope to claim your attention, because in so doing, I wish to make an attempt to weaken one of the chief arguments against the theory of evolution, an argument which was termed by Huxley "the stock objection."[1]

I wish to speak to you about the hypothesis of accelerated development by primogeniture and its place in the theory of evolution.

I must begin with calling to mind that provisionally it is not upon the firm basis of proved facts, but more upon the quicksands of theoretical conjecture that we shall be moving. Our track first leads us into the domain of a science which is of such an exceptional value for the theory of evolution, because this science only, the science of palæontology, can furnish us with direct evidence towards the truth of that theory.

If, indeed, living organisms form one continuous chain with those that have already become extinct; if these organisms have not been called into life in successive periods by repeated creative acts but if they are in direct blood-relationship to each other—a relation which as we penetrate further into the past must be accompanied by a simplification of organisation—then palæontology must furnish us with the evidence of this process. Then, indeed, the superposed strata which have been deposited since the cooling of the earth's crust under the combined influence of internal vulcanism and external atmospherical influences, must contain the archives in which the most trustworthy and direct proof for the validity of the theory of evolution are to be found. Moreover, the material which we find heaped in these archives must show—if we place confidence in it—that gradual increase of complication which accompanies the development of the more highly differentiated forms out of simpler types by the aid of natural selection, in a succession exactly corresponding to that of the deposition of the strata. We know how far palæontology had advanced in 1859, we understand how it was that Darwin insisted on the imperfection of the geological record in the first edition of his "Origin of Species." He diligently collected arguments to explain this incompleteness and to oppose the objection against his doctrines which it might furnish. I cannot at present enter into details concerning this refutation. Still it is quite as valid to-day. So many deposits are wholly devoid of animal remains, it is so obvious that of other animal forms, fossils can hardly ever have been formed, and lastly, only such a small portion of the earth's surface has been adequately searched, that we have indeed more reason to be astonished at the quantity of facts that have already come to our knowledge, than at the much larger quantity which yet remains hidden from our view.

This is especially present to our minds when we remember the invaluable deposits that have of late years been opened up in North America, where not only the successive periods of the tertiary epoch form extensive deposits, but where they moreover contain perfectly preserved animal specimens which have lived in these successive periods, and which indeed show in the most irrefutable way that a direct connection accompanied by an increase of differentiation undeniably exists. We here find a very remarkable page of the book thrown open upon which nature has written down for us the history of the development of the horse, and whoever has learnt to read this handwriting is brought to the inevitable conclusion: this development has started from an older form of a less specialised organisation, and has proceeded along successive steps which are entirely in accordance with the theory of evolution.

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[1] T. H. Huxley, American Addresses.

Similarly the numerous remains of the fossil group of the Ornithoscelidæ are only known since a recent date, and a gradually increasing knowledge is thus attained of those interesting animals which link together reptiles and birds, two classes of animals which were formerly looked upon as amongst the most thoroughly separated.

Together with these irrefutable proofs that evolution has indeed taken place, starting from the simpler, more generalised types, and tending towards the more complicated and more specialised forms, palæontology acquaints us with certain other facts. I allude to the persistence of the same form, of the same genus, sometimes even of the same species in all successive strata and periods. Thus, for example, among Mollusks, Chiton and Pleurotomaria have persisted from the Silurian down to the present period; Dentalium from the Devonian; Pinna and Cyprina from the Carboniferous period. Amongst the Foraminifera certain genera occur in the Carboniferous epoch, which at the same time are members of the living fauna. Amongst Brachiopods our living Lingulas, Rhynchonellas, and Terebratulas are very ancient types; representatives of the osseous fishes lived in the Cretaceous period, which cannot be generically distinguished from their living relatives, whilst certain genera of cartilaginous fishes reach even into a much farther distant past.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

Oxford.—Owing to the early occurrence of Easter, the term has begun a week earlier than usual this year. The first University business of importance will be the constitution of the New Boards of Faculties. These will consist of the professors as *ex-officio* members, and of members elected by the College lecturers in the various faculties, the number to be so elected being first decided by vote. The first step towards the new state of things has been the appointment of Mr. Lockhart, of Hertford College, as General Secretary to the Board of Faculties.

In the department of Physics at the University Museum, Prof. Clifton continues his course on the Electricity Developed by the Contact of different Substances; Mr. Stocker lectures on Mechanics, and Mr. Heaton on Problems on Mechanics and Physics. Prof. Price continues his course on Optics, and also gives a course on Hydro-mechanics.

Prof. Pritchard is absent in Egypt completing his measurements of the magnitude of the stars. The observatory will be open on Tuesday and Thursday evenings under the charge of Mr. Plummer.

In the Chemical Department of the Museum, Prof. Odling will give a course on Elementary Facts and Doctrines. Mr. Fisher will lecture on Inorganic Chemistry, and Dr. Watts on Organic Chemistry. The laboratory will lose the services of Mr. F. D. Brown in the middle of the term, as he has been elected to the Professorship of Chemistry and Physics in the New University at Auckland, and leaves for New Zealand in March.

In the Biological Department Prof. Moseley continues his course on Comparative Anatomy (followed by practical work). Mr. Hatchett Jackson lectures on the Fundamental Principles of Embryology, Mr. Poulton on the Geographical Distribution of Animals, Mr. Lewis Morgan on the Teeth of Vertebrata and on Human Osteology, and Mr. Hickson on Histology. Mr. Barclay Thompson has been obliged to give up lecturing on account of ill health.

Prof. Prestwich gives a course of lectures on Stratigraphical Geology.

The following courses will be given in the private College laboratories:—At Christchurch Mr. Vernon Harcourt lectures and gives practical instruction in Quantitative Analysis, and Mr. Baynes on Thermo-dynamics. At Balliol Mr. Dixon lectures on Organic Chemistry, and Elementary Electricity. At Magdalen Mr. Yule gives a course of demonstrations on the Chemical and Physical Properties of the Blood, Circulation, Respiration, &c.; and Mr. Chapman gives a practical course on Elementary Vegetable Morphology.

A scholarship in Natural Science will be offered at Keble College of the value of 80*l.* per annum. The examination will be in Biology and Chemistry; a scholarship will also be offered for competition at Queen's College in Physics, Chemistry, or Biology.

Cambridge.—Mr. J. E. Marr, M.A., Fellow of St. Johns College, is the Sedgwick Prizeman this year.

Science lectures commence on the following days: Prof. Liveing, General Principles of Chemistry, January 23; Prof. Dewar, Organic Chemistry, January 23; Prof. Newton, Geographical Distribution of Vertebrate Animals, January 31; Mr. Caldwell, Morphology of Invertebrata, Advanced, February 1; Dr. Hans Gadow, Morphology of Vertebrata, Advanced, January 30.

The names of Messrs. Casey (Trin.), Harvey (King's), A. R. Johnson (St. John's), Turner (Trin.), and Welsh (Jesus) appear in alphabetical order in the First Division of the List for the Third Part of the Mathematical Tripos, to which only the Wranglers were admitted. One name is in the second division, and eight in the third.

Mr. F. J. M. Page, B.Sc., F.C.S., of University College, London, was elected, on January 11, Lecturer on Physics at the London Hospital Medical College.

SCIENTIFIC SERIALS

Journal of the Franklin Institute, December, 1882.—An improved dynamometer, by W. P. Tatham.—The isochronal Worthington pumping engine, by J. K. Maxwell.—Explosive and dangerous dusts, by T. W. Tobin.—Economical steam power (continued), by W. B. Le Van.—The universality of vibrations, by C. C. Haskins.—Report on European sewerage systems, &c. (continued), by R. Hering.

Annalen der Physik und Chemie, No 13 (December 2, 1882).—Absolute measurements with bifilar suspension, and especially two methods for determining the horizontal intensity of terrestrial magnetism without time measurement, by F. Kohlrausch.—The reduction of the Siemens unit to absolute measure, by E. Dorn.—On electric vibrations with special regard to their phases, by A. Oberbeck.—Experimental researches on galvanic polarisation, by F. Streintz.—On M. A. Guebhard's representation of equipotential curves, by E. Mach.—The electromotive force of the Daniell element, by E. Kittler.—On amalgamation-currents, by H. Haga.—Explanation of electric shadows in free air, by P. Riess.—On the material parts in electric sparks, by F. Wächter.—On the magnetic screening action of iron, by J. Stefan.—On tone-vibrations of solid bodies in presence of liquids, by F. Auerbach.—A small alteration of the pyknometer, by E. Wiedemann.—Remark on Herr Galn's memoir on the density of the luminiferous ether, by the same.—On the true cohesion of liquids, by the same.—On the condensation of liquids on solid bodies, by the same.—The leucoscope and some observations made with it, by A. König.—Contribution to the theory of diffraction in telescope-tubes, by H. Struve.—On the elliptical polarisation of reflected diffracted light, by W. Kœnig.—On the Poggendorff fall-machine, by K. L. Bauer.—Contributions to the history of natural sciences among the Arabs, viii. and ix., by E. Wiedemann.

Bulletin de l'Academie Royale des Sciences de Belgique, Nos. 9 and 10.—Notice on a peculiarity in the aurora borealis of October 2, 1882, and on the increase in intensity of scintillation of stars during auroræ, by C. Montigny.—Some theorems of elementary geometry, by E. Catalan.—On curves of the third order, by C. Le Paige.—Aspect of the great comet of 1882 (Cruls) observed at Louvain, by F. Terby.—Note on the aurora borealis of October 2, 1882, by the same.—Action of chlorine on tertiary butylic chloride, by Baron d'Otreppe de Buvette.

No. 11.—Note on some bones of the Biscay whale at the